

1        THERMOPLASTIC DOOR SKINS AND METHOD OF MANUFACTURE THEREOF

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3                    Background of the Invention

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5        The present invention relates to materials for forming  
6        door skins for use in manufacturing doors and the process  
7        for forming the door skins.

8        Doors are increasingly being manufactured from plastic  
9        components. Typical door assemblies comprise a pair of  
10      compression molded exterior skins, having wood grain  
11      patterns on their outer surfaces, which are mounted on a  
12      rectangular frame which separates and supports the skins in  
13      spaced apart relationship. The hollow space between the  
14      skins is filled with foam, such as a polyurethane foam.  
15      These composite door assemblies resist rot or corrosion and  
16      are generally better insulators than wood or metal doors.  
17      Because of material costs and manufacturing efficiencies,  
18      composite door assemblies are considerably less expensive to  
19      manufacture than wood doors and can be designed to provide a  
20      reasonable facsimile of a wood grain door.

21       The compression molding process utilized in  
22      manufacturing currently available door assembly skins does  
23      have limitations which effect the efficiency of the molding  
24      process and place limitations on the design of the skins. A  
25      typical compression molding process involves manually

1 placing a first rectangular sheet of a thermosetting resin  
2 within a lower mold half corresponding to the shape of the  
3 outer surface of the door skin. A sheet of reinforcing  
4 material, typically a fiberglass mat, is placed on top of  
5 the first sheet of thermosetting resin and then a second  
6 sheet of thermosetting resin is placed on top of the  
7 fiberglass mat. An upper mold half is then advanced into  
8 engagement with the lower mold half to compress the layered  
9 materials therebetween and the mold is heated to cause the  
10 layers of thermosetting resin to melt, disperse through or  
11 bond with the reinforcing material and to conform to the  
12 shape of the mold. Further compression and heating of the  
13 mold and subsequent cooling thereof causes the thermosetting  
14 material to set in the molded shape. After setting, the  
15 thermosetting process generally cannot be reversed and any  
16 finished material which is flawed, scrapped or otherwise  
17 rejected must be disposed of typically in an expensive  
18 controlled landfill.

19 In a simple compression molding process as described  
20 above, the resulting molded structure including structural  
21 elements molded therein must be of a relatively consistent  
22 thickness. The addition of relatively thicker structural  
23 elements in the door skin or the addition of structural  
24 elements which require the displacement of a considerable  
25 amount of molding material away from the face of the door

1 skin require the use of secondary molding steps to build up  
2 the structural element. Such secondary molding steps  
3 significantly add to the molding cost and the cost of the  
4 finished product.

5 Thermoplastics can be reused and it is known that a  
6 molded part of varying thickness can be produced in a closed  
7 injection molding process. However, due to cost  
8 considerations, a closed injection molding process is  
9 generally impractical for the commercial production of door  
10 skins.

11 There remains a need for improved door skin designs  
12 which facilitate assembly of the door skins and reduce  
13 manufacturing costs. Although others have discussed the  
14 possibility of thermoplastic door skins, to applicant's  
15 knowledge no one has successfully produced a thermoplastic  
16 door skin. In particular, U.S. Patent No. 5,644,870  
17 mentions that the door skins disclosed therein can be formed  
18 from thermoplastic material, but the disclosure is not  
19 enabling for use of thermoplastic materials.

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21 Summary of the Invention

22 The present invention comprises a composite door  
23 assembly including door skins which are formed from  
24 thermoplastic material. In a preferred embodiment, the  
25 thermoplastic material used to form the door skin is a

1 polypropylene copolymer resin. Additives including  
2 reinforcing glass fiber strands, fillers such as talc, a UV  
3 stabilizer such as a benzotriazole and pigment are also  
4 utilized in combination with the thermoplastic material.  
5 The door skins are formed in a thermoplastic flow forming  
6 process wherein the molten thermoplastic molding material  
7 including additives flows from a flow controlled die onto a  
8 lower mold half for the skin which is moving below the die.  
9 The flow of molten molding material through the die is  
10 controlled such that the amount of molding material laid  
11 down in a particular area of the mold generally corresponds  
12 to the desired thickness of the portion of the molded part  
13 at that area. After the lower mold half is filled, it is  
14 advanced to a press and an upper mold half is advanced into  
15 engagement with the lower mold half to form the door skin  
16 therebetween. After cooling, the mold halves are separated  
17 and the molded skin is ejected.

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1                   Brief Description of the Drawings

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3                 Figure 1 is a front plan view of a door assembly.

4                 Figure 2 is an enlarged and fragmentary cross-sectional  
5                 view taken along line 2-2 of Figure 1.

6                 Figure 3 is an enlarged and fragmentary top plan view  
7                 of the door assembly as in Figure 1.

8                 Figure 4 is an enlarged and fragmentary front plan view  
9                 of a rear skin of the door assembly.

10                Figure 5 is an enlarged and fragmentary front  
11                perspective view of the rear skin of the door assembly.

12                Figure 6 is an enlarged and fragmentary cross-sectional  
13                view taken along line 6-6 of Figure 1.

14                Figure 7 is an exploded perspective view of the door  
15                assembly without a layer of foam injected between the front  
16                and rear skins.

17                Figure 8 is a schematic diagram of a thermoplastic flow  
18                forming process by which skins of the door assembly are  
19                produced.

1                   Detailed Description of the Invention

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3                 As required, detailed embodiments of the present  
4 invention are disclosed herein; however, it is to be  
5 understood that the disclosed embodiments are merely  
6 exemplary of the invention, which may be embodied in various  
7 forms. Therefore, specific structural, compositional and  
8 functional details disclosed herein are not to be  
9 interpreted as limiting, but merely as a basis for the  
10 claims and as a representative basis for teaching one  
11 skilled in the art to variously employ the present invention  
12 in virtually any appropriately detailed structure,  
13 composition or process.

14               Referring to the drawings in more detail, the reference  
15 numeral 1 refers to a door assembly. As generally shown in  
16 Figures 1 through 6, the door assembly 1 comprises a pair of  
17 opposed or front and rear door panels or skins 5 and 6. The  
18 door assembly 1 is an example of the type in which the  
19 components, including skins 5 and 6 may be formed using  
20 thermoplastic material and formed using a thermoplastic flow  
21 forming process.

22                   Door Skin Assembly Construction

23               The front and rear skins 5 and 6 are connected together  
24 by connectors 8, 9 and 10 and mounted on frame 12. Frame 12  
25 comprises first and second stiles 13 and 14, top rail 15 and

1 bottom rail 16. The interior space 19 between the skins 5  
2 and 6 is filled with a polyurethane foam 20 which is  
3 injected therein after assembly of the skins 5 and 6, with  
4 connectors 8, 9 and 10 on the stiles 13 and 14 and top rail  
5 15 of frame 12. The bottom rail 16 is inserted and secured  
6 between lower ends of stiles 13 and 14 after injection of  
7 polyurethane foam 20 within the interior space 19.

8 Skins 5 and 6 are identical in construction. An outer  
9 or exterior surface 25 of each skin 5 and 6 is textured  
10 during the molding process to imitate a wood grain texture.  
11 A tongue is formed on an inner surface 27 of each skin 5 and  
12 6 and extends around the outer periphery of the sides and  
13 the top thereof. In particular, a first side tongue 30  
14 extends along a first side edge 31 of each of the skins 5  
15 and 6, a second side tongue 32 extends along a second side  
16 edge 33 of each of the skins 5 and 6, and a top tongue 34  
17 extends along a top edge 35 of each of the skins 5 and 6.

18 Outer surfaces of the first side tongue 30 and the  
19 second side tongue 32 extend flush with the first side edge  
20 31 and the second side edge 33 respectively. The top tongue  
21 34 is spaced inward from the top edge 35 of each of the  
22 skins 5 and 6 so as to form a top lip or shoulder 38  
23 extending outward from or above the top tongue 34. The  
24 interior portion 39 of each skin 5 and 6 is of a relatively  
25 thin and uniform thickness. For illustrative purposes, the

1     interior portion 43 of each skin 5 and 6 is approximately  
2     0.085 inches thick. The first side, second side and top  
3     tongues 30, 32 and 33 extend rearward from the inner surface  
4     27 of the skins 5 and 6 approximately 0.54 inches and are  
5     approximately 0.187 inches thick or at least twice as thick  
6     as the interior portion 43 of the skins 5 and 6. The top  
7     tongue 34 is spaced inward from the top edge 35  
8     approximately 0.187 inches by top lip or shoulder 38 which  
9     is approximately 0.250 inches thick.

10       The first side tongue 30 and the second side tongue 32  
11     extend from the top edge 35 of each skin 5 and 6 to a bottom  
12     edge 40 thereof. First and second ends 41 and 42 of the  
13     third or top tongue 34 are spaced apart from the first and  
14     second side tongues 30 and 32 respectively by first side and  
15     second side channels 43 and 44.

16       Opposed skins 5 and 6 are connected together using two  
17     side connectors 8 and 9 and top connector 10. The  
18     connectors 8, 9 and 10 are of an identical H-shaped cross-  
19     section and preferably formed from a single extrusion cut to  
20     the desired lengths. The side connectors 8 and 9 are of  
21     identical length, equal to the length of the first and  
22     second tongue sections 30 and 32. The top connector 10 is  
23     shorter than the side connectors 8 and 9 and slightly longer  
24     than the top tongue 34, as discussed in more detail below.

1       Each of the connectors 8, 9 and 10 includes inner and  
2   outer walls 55 and 56 connected together medially by cross-  
3   member or web 57, so as to form first and second tongue  
4   receiving grooves 58 and 59 extending longitudinally between  
5   the inner and outer walls 55 and 56. The grooves 58 and 59  
6   are sized to mate with the tongue sections 30, 32 and 34.  
7   The width of the grooves 58 and 59 corresponds to the width  
8   of the tongue sections 30, 32 and 34, which in the  
9   embodiment as noted above is approximately 0.187 inches.  
10   The outer wall 56 is approximately 0.187 inches thick which  
11   is approximately at least as thick as most door hinge leaves  
12   to permit portions of the outer wall 56 to be removed to  
13   form a recess for receiving a hinge leaf without having to  
14   cut into the skins 5 or 6 themselves. The inner wall 55 is  
15   slightly narrower to conserve material.

16       The corners of the connectors 8, 9 and 10 which engage  
17   portions of the tongues 30, 32 and 34 and the corresponding  
18   corners of the tongues 30, 32 and 34 are radiused to provide  
19   additional strength at the corners.

20       The skins 5 and 6 are connected together by first  
21   placing connectors 8, 9 and 10 on first side tongue 30,  
22   second side tongue 32 and top tongue 34 respectively of  
23   first skin 5 such that the tongues 30, 32 and 34 extend into  
24   the first tongue receiving grooves 58 of connectors 8, 9 and  
25   10 respectively. Upper ends of side connectors 8 and 9

1 extend through the first and second side channels 43 and 44  
2 respectively between the first side and second side tongues  
3 30 and 32 and the top tongue 34 respectively. The channels  
4 43 and 44 are slightly wider than the inner walls 55 of each  
5 connector 8 and 9 to ensure that the upper ends of the  
6 connectors 89 may pass therethrough without binding. The  
7 top connector 10 is sized to completely span the distance  
8 between interior surfaces of the inner walls 55 of the  
9 connectors 8 and 9.

10 An adhesive is applied to the tongues 30, 32 and 34 or  
11 within the first tongue receiving grooves 58 prior to  
12 attachment of the connectors 8, 9 and 10 to tongues 30, 32  
13 and 34. The frame 12 is then secured to the first skin 5.  
14 In particular, the first and second stiles 13 and 14, top  
15 rail 15 and bottom rail 16 are positioned against the inner  
16 surface 27 of the first skin 5 such that the first and  
17 second stiles 13 and 14 abut against the inner walls 55 of  
18 side connectors 8 and 9 and top rail 15 abuts against the  
19 inner wall 55 of top connector 10. An adhesive is applied  
20 to the frame components to secure the stiles 13 and 14 and  
21 top rail 15 to the skin 5 and connectors 8, 9 and 10  
22 respectively and to secure the bottom rail 16 to skin 5.  
23 The bottom rail 16 is generally positioned such that a  
24 bottom edge 62 of the bottom rail 16 generally extends flush  
25 with the bottom edge 40 of the skin 5. It is foreseen that

1 the frame 12 may be assembled prior to attachment to the  
2 skin 5.

3       The rear skin 6 is then secured in place by inserting  
4 first side, second side and top tongues 30, 32 and 34 of  
5 skin 6 in the second tongue receiving grooves 59 of  
6 connectors 9, 8 and 10 respectively. The tongues 30, 32 and  
7 34 are secured within the second tongue receiving grooves 59  
8 by gluing. The bottom rail 16 may also be glued to inner  
9 surfaces 27 of the front and rear skins 5 and 6.

10      The skins 5 and 6, with the frame positioned therein,  
11 are held together in a jig (not shown) and polyurethane foam  
12 20 is injected into the interior space 19 between the skins  
13 5 and 6 through a nozzle (not shown) inserted through a hole  
14 65 in the bottom rail 16. After the foam 20 is injected  
15 between the skins 5 and 6 a plug 66 is inserted into the  
16 hole 65 and glued to the bottom rail 16 to seal off the hole  
17 65.

18      A lock block 70 is formed on first stile 13 to provide  
19 structure into which a hole for a knob may be bored and to  
20 which a knob (not shown) may be secured. It is to be  
21 understood that the second stile 14 is sufficiently thick,  
22 to receive screws (not shown) for securing hinges (not  
23 shown) thereto.

24      When the door assembly 1 is assembled, the outer walls  
25 56 of side connectors 8 and 9 extend beyond the first and

1 second side edges 31 and 33 of the skins 5 and 6, while the  
2 outer wall 56 of top connector 10 extends flush with the top  
3 edge 35 of the skins 5 and 6. Portions of the outer walls  
4 56 of the side connector 9 are typically cut away to form  
5 recesses into which a leaf from a door hinge (not shown) may  
6 be positioned. Portions of the outer walls 56 of the side  
7 connectors 8 and 9 may be trimmed to ensure a proper fit of  
8 the door assembly 1 within a door jamb. Similarly the  
9 bottom rail 16 is adapted to permit trimming thereof to  
10 ensure a proper fit of the door.

11 It is foreseen that the first side and second side  
12 tongues 30 and 32 could also be spaced inward from the first  
13 and second side edges 31 and 33 similar to the top tongue  
14 34, such that the outer walls 56 of side connectors 8 and 9  
15 extend flush with the first and second side edges 31 and 33  
16 of the skins 5 and 6 when assembled.

17 The stiles 13 and 14 and top rail 15 can be formed from  
18 thermoplastic material but are preferably formed from wood  
19 which provides a desired rigidity for the assembled door.  
20 Further, wood of the quality and type suitable for use in  
21 forming the stiles 13 and 14 and top rail 15 is generally  
22 readily available and relatively inexpensive. Further, door  
23 assemblers are familiar with and have the tools necessary  
24 for constructing and handling wooden frames 12. It is

1 foreseen that the frame components could also be formed from  
2 thermoplastic material or other suitable materials.

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5                   Thermoplastic Molding Materials

6         As noted above, the skins 5 and 6 are formed from a  
7 composite molding material comprising a thermoplastic  
8 material in combination with additives, reinforcing fibers  
9 and/or fillers. A preferred composite molding material  
10 comprises, by weight percent, 66-67% polypropylene copolymer  
11 resin, 15% glass fiber strands 4mm (.16 inches) long and  
12 .0035 mm (.00014 inches) in diameter, 15% talc, 1-2% UV  
13 stabilizer(such as a benzotriazole)and 2-3% pigment. The  
14 concentrations provided are approximations and it is to be  
15 understood that a wide variety of concentrations may be  
16 utilized. In particular, it is foreseen that the  
17 concentration of polypropylene could range from  
18 approximately 50% to approximately 100%. However, in most  
19 applications a concentration of glass fibers of at least 10%  
20 would be preferred along with additional additives, such  
21 that the preferred range for the concentration of  
22 polypropylene would range from 50% to 85%. It is foreseen  
23 that the concentration of glass fibers would preferably  
24 range from 10% to 20%.

1       Another composite thermoplastic material might comprise  
2   approximately eighty percent(80%) by weight high impact  
3   polystyrene with (20%) twenty percent by weight wood fiber.  
4   Other thermoplastics which might be utilized include;  
5   acrylonitrile-butadiene-styrene, acetal, nylon, polyester,  
6   polypropylene, polyethylene, polyvinyl chloride and acrylic.

7       The talc is used as a filler and its ability to add  
8   rigidity and stiffness and for thermal stability. Other  
9   fillers which could be utilized include calcium carbonate  
10   and cellulose such as the wood fiber noted above. Although  
11   glass fibers are disclosed as the reinforcing fibers it is  
12   foreseen that other fibers including carbon fibers could be  
13   utilized. Similarly, a wide

14       The connectors 8, 9 and 10 are preferably also formed  
15   from the composite molding material in an extrusion process.

16       In the preferred embodiment, the connectors 8, 9 and 10  
17   are formed separate from the stiles 13 and 14 and top rail  
18   15 respectively. However it is foreseen that the connectors  
19   8, 9 and 10 could be integrally formed with the stiles 13  
20   and 14 and the top rail 15 such that the stiles 13, 14 and  
21   15 incorporate the connectors 8, 9 and 10 respectively.

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23                   Method of Manufacturing Door Skins

24       The skins 5 and 6 are formed from the composite molding  
25   material using a thermoplastic flow forming process. A

1 process diagram is shown in Figure 8. In the preferred  
2 embodiment, the polypropylene is usually provided in pellet  
3 form, the talc and the UV stabilizer as a powder and the  
4 pigment in either pellet or powder form.

5 The original ingredients are fed in dry form into a  
6 mixing hopper 101 mounted opposite the output end of an  
7 extruder 104. The hopper 101 is of a type which weighs each  
8 component independently, mixes the components and  
9 gravimetrically feeds it into the extruder 104. The  
10 extruder melts the composite thermoplastic material and  
11 ejects the molten molding material into a sheet die 106.

12 Molten molding material flows out of the die 106  
13 through an outlet 107 (not shown). Molten molding material  
14 flows out of the outlet 107 into a first pair of lower or  
15 first mold halves 111 and 112 as the lower mold halves 111  
16 and 112 are advanced beneath the outlet 107 to the sheet die  
17 106. The first pair of lower mold halves 111 and 112 are  
18 supported in side by side relationship on a first trolley  
19 113 which is moveably mounted on rails 115 and 116 which  
20 extend transverse to the sheet die outlet 107. The outlet  
21 107 is approximately as wide as the distance across the  
22 first pair of lower mold halves 111 and 112. Each of the  
23 lower mold halves 111 and 112 is shaped to form a first side  
24 or face of a door skin, such as skins 5 or 6.

1       The molten molding material flows into the lower mold  
2   halves 111 and 112 generally as a sheet as the mold halves  
3   110 and 111 pass therebeneath on trolley 113. The size and  
4   shape of the outlet 107 and the flowrate of molding material  
5   through the die 106 is controlled by a computer control  
6   system 118 such that the amount of molding material flowing  
7   into a particular area of a lower mold half 111 or 112  
8   generally corresponds to the amount of material necessary to  
9   achieve the desired thickness of the molded part in that  
10   area.

11       The lower mold halves 111 and 112 are then advanced on  
12   the first trolley 13 into a first compression press 120 and  
13   below a first pair of adjacently aligned upper mold halves  
14   121 and 122 (not shown) already positioned in the  
15   compression press 120. The upper mold halves 121 and 122  
16   are then advanced into engagement with the lower mold halves  
17   111 and 112 and the molding material is compressed  
18   therebetween expelling any air trapped therebetween and  
19   allowing the molten material to fill out and conform to the  
20   shape of a molding cavity formed between the upper mold  
21   halves 121 and 122 and the lower mold halves 111 and 112.

22       Cooling water, from a cooling system 124 is circulated  
23   through or around the mold halves 111 and 112 and 121 and  
24   122 to cool the molded part or door skin 125 formed  
25   therebetween. Once sufficient time elapses to permit

1 adequate cooling, the mold halves 111 and 112 and 121 and  
2 122 are separated in the compression press 120 and the door  
3 skins are removed from between the upper mold halves 121 and  
4 122 and the lower mold halves 111 and 112 by a vacuum  
5 extraction tool 127.

6 A second pair of lower mold halves 131 and 132 are  
7 secured on a second trolley 133 (not shown) which is  
8 moveably mounted on rails 115 and 116. When the first  
9 trolley 113 is in the first compression press 120, the  
10 second trolley 133 is advanced beneath the sheet die 106 and  
11 molten molding material flows through the outlet 107 thereof  
12 into the second pair of lower mold halves 131 and 132. The  
13 second trolley 133 beneath the sheet die 106 in a direction  
14 opposite to which the first trolley 113 passes beneath the  
15 die 106. After the second pair of lower mold halves 131 and  
16 132 pass completely beneath the sheet die 106, they are  
17 advanced on the second trolley 133 into a second compression  
18 press 140 and beneath a second pair of adjacently aligned  
19 upper mold halves 141 and 142 (not shown). The second  
20 compression press 140 is positioned on a side of the sheet  
21 die 106 opposite the first compression press 120. The  
22 second pair of upper mold halves 141 and 142 are then  
23 advanced into engagement with the second pair of lower mold  
24 halves 131 and 132 and the molding material is compressed  
25 therebetween expelling any air trapped therebetween and

1 allowing the molten material to fill out and conform to the  
2 shape of a molding cavity formed between the upper mold  
3 halves 141 and 142 and the lower mold halves 131 and 132.

4 Cooling water, from the cooling system 124, is  
5 circulated through or around the mold halves 131 and 132 and  
6 141 and 142 to cool the molded part or door skin 125 formed  
7 therebetween. Once sufficient time elapses to permit  
8 adequate cooling, the mold halves 131 and 132 and 141 and  
9 142 are separated in the compression press 140 and the door  
10 skins are removed from between the upper mold halves 141 and  
11 142 and the lower mold halves 131 and 132 by a second vacuum  
12 extraction tool 148.

13 As the second pair of upper and lower mold halves 141  
14 and 142 and 131 and 132 are being compressed and separated  
15 in the second compression press 140, the first trolley 113  
16 is advanced out of the first compression press 120 past and  
17 then back under the sheet die 106 toward the first  
18 compression press 120 such that one pair of lower mold  
19 halves 111 and 112 or 131 and 132 is being filled while the  
20 other set is in the associated compression press 120 or 140.  
21 The movement of the trolleys 113 and 133 is controlled by  
22 the computer control system 118.

23 If the resulting door skin or molded part 125 is  
24 flawed, the skin may be ground into relatively small pieces  
25 which are fed back to the hopper 101 for reuse. Similarly,

1 any excess molding material purged or trimmed from between  
2 the upper and lower mold halves may be ground and fed back  
3 to the hopper 101 for reuse.

4 It is to be understood that while certain forms of the  
5 present invention have been illustrated and described  
6 herein, it is not to be limited to the specific forms or  
7 arrangement of parts described and shown.